Conversely, storage in BU may keep the larvae within their "activity sphere" (Croll, 1972), i.e., the optimum physiological parameters for activity and survival, thereby allowing them to remain responsive to environmental signals. Indeed, larvae of *A. ceylanicum* and *Necator americanus* stored in BU for 3–4 wk were capable of causing patent infections in hamsters, although their infectivity compared to water-stored larvae was not examined. The percentage of hookworm L_3's that resume feeding in vitro has not been correlated directly with infectivity, but the level of feeding exhibited by larvae stored in BU suggests that these larvae retain the ability to respond to the host signals encountered during infection.

Literature Cited

Clark, F. E. 1969. *Ancylostoma caninum*: food reserves and changes in chemical composition with age in third stage larvae. Experimental Parasitology 24:1–8.

Clokey, G. V., and L. A. Jacobson. 1986. The autofluorescent "lipofuscin granules" in the intestinal cells of *Caenorhabditis elegans* are secondary lysosomes. Mechanisms of Ageing and Development 35:79–94.

Croll, N. A. 1972. Energy utilization of infective *Ancylostoma tubaeforme* larvae. Parasitology 64:355–368.

———, and B. E. Matthews. 1973. Activity, ageing, and penetration of hookworm larvae. Parasitology 66:279–289.

———, L. Slater, and J. M. Smith. 1972. *Ancylostoma tubaeforme*: osmoregulatory ampulla of larvae. Experimental Parasitology 31:356–360.

Hawdon, J. M., and G. A. Schad. 1990. Serum-stimulated feeding in vitro by third stage infective larvae of the canine hookworm *Ancylostoma caninum*. Journal of Parasitology 76:394–398.

Weinstein, P. P. 1952. Regulation of water balance as a function of the excretory system of the filariform larvae of *Nippostrongylus muris* and *Ancylostoma caninum*. Experimental Parasitology 1:363–376.

Research Note

Helminths of Three Toads, *Bufo alvarius, Bufo cognatus* (Bufonidae), and *Scaphiopus couchii* (Pelobatidae), from Southern Arizona

Stephen R. Goldberg[1] and Charles R. Bursey[2]

[1] Department of Biology, Whittier College, Whittier, California 90608 and

[2] Department of Biology, Pennsylvania State University, Shenango Valley Campus, 147 Shenango Avenue, Sharon, Pennsylvania 16146

ABSTRACT: The gastrointestinal tracts and lungs of 3 toad species were examined for helminths. Examination of 95 *Bufo alvarius* revealed the presence of the nematodes *Aplectana itzocanensis* Bravo Hollis, 1943, *Physaloptera* sp. Rudolphi, 1819, *Physocephalus* sp. Diesing, 1861, *Oswaldocruzia pipiens* Walton, 1929, the cestode *Nematotaenia dispar* (Goeze, 1782) Lühe, 1899, in the gastrointestinal tract, and the nematode *Rhabdias americanus* Baker, 1978, in the lungs. *Bufo cognatus* ($N = 21$) had the nematodes *A. itzocanensis, O. pipiens, Physaloptera* sp., and the cestode *Distoichometra bufonis* Dickey, 1921, in the gastrointestinal tract. The nematode *R. americanus* was found in the lungs. *Scaphiopus couchii* ($N = 76$) had the nematodes *Aplectana incerta* Caballero, 1949, and *O. pipiens,* and the cestode *D. bufonis* in the digestive trace. No helminths were found in the lungs of *S. couchii.*

KEY WORDS: Nematoda, *Aplectana incerta, Aplectana itzocanensis, Physaloptera* sp., *Physocephalus* sp., *Oswaldocruzia pipiens, Rhabdias americanus,* Cestoda, *Distoichometra bufonis, Nematotaenia dispar,* prevalence, intensity, survey, Bufonidae, *Bufo alvarius, Bufo cognatus,* Pelobatidae, *Scaphiopus couchii.*

The Colorado River toad, *Bufo alvarius,* the Great Plains toad, *Bufo cognatus,* and Couch's spadefoot, *Scaphiopus couchii,* occur sympatrically in southern Arizona. *Bufo alvarius* ranges across southern Arizona and extreme southwestern New Mexico to northwest Sinaloa, Mexico from sea level to 1,610 m. *Bufo cognatus* has a geographic range extending from extreme

Table 1.   Prevalence (%), intensity, range, and location of helminths from *Bufo alvarius, Bufo cognatus,* and *Scaphiopus couchii.*

	Bufo alvarius			Bufo cognatus			Scaphiopus couchii		
Parasite	Preva-lence	$\bar{x}$ Intensity (range)	Loca-tion*	Preva-lence	$\bar{x}$ Intensity (range)	Loca-tion*	Preva-lence	$\bar{x}$ Intensity (range)	Loca-tion*
Cestoidea									
Distoichometra bufonis	—	—	—	19	4 (1–6)	c, d	20	3 (1–11)	c, d
Nematotaenia dispar	67	7 (1–39)	c, d	—	—	—	—	—	—
Nematoda									
Aplectana incerta	—	—	—	—	—	—	82	74 (2–447)	d
Aplectana itzocanensis	52	33 (1–371)	c, d	5	1 (1)	d	—	—	—
Oswaldocruzia pipiens	49	3 (1–9)	b, c, d	38	6 (1–17)	b, c, d	11	21 (1–13)	b, c
Physaloptera sp.	38	7 (1–77)	a, b, d	14	1 (1)	b	—	—	—
Physocephalus sp.	2	9 (1–12)	b, c	—	—	—	—	—	—
Rhabdias americanus	65	7 (1–34)	e	38	7 (1–21)	e	—	—	—

* a = esophagus; b = stomach; c = small intestine; d = large intesstine; e = lung.

southern Canada to San Luis Potosi, Mexico from near sea level to 2,440 m. *Scaphiopus couchii* ranges from southwestern Oklahoma, central New Mexico, and south central Arizona to the tip of Baja California, Nayarit, and southern San Luis Potosi, Mexico (Stebbins, 1985). To our knowledge there are no reports on the helminth fauna of *B. alvarius.* There are 2 reports of *B. cognatus* as a host (Kuntz, 1940, 1941) and 5 reports for *S. couchii* (Kuntz, 1940, 1941; Tinsley and Jackson, 1986, 1988; Baker, 1987). The purpose of this note is to describe the prevalences and intensity of the helminth fauna from southern Arizona populations of these 3 toad species.

Ninety-five *B. alvarius* (mean snout–vent length, SVL = 126 ± 21 mm, range 71–162 mm) and 21 *B. cognatus* (mean SVL = 79 ± 12 mm, range 55–98 mm) were hand collected during July 1985 at Robles Junction, Pima County, Arizona (32°04′N, 111°18′W, 712 m elevation). Seventy-six *S. couchii* (mean SVL = 63 ± 4 mm, range 55–77 mm) were hand collected along Drexel Road at Arizona Highway 89, Pima County, Arizona (32°09′N, 110°59′W, 743 m elevation). Toads were fixed in neutral, buffered 10% formalin. The body cavity was opened by a longitudinal incision from vent to throat and the gastrointestinal tract was excised by cutting across the anterior esophagus and the rectum. The lungs were also removed for examination; no other organs were removed. Esophagus, stomach, small intestine, large intestine, and lungs were examined separately. Each organ was slit longitudinally and examined under a dissecting microscope. Each helminth was removed and identified utilizing a glycerol wet mount. Rep-

resentative cestodes were stained with hematoxylin and mounted in balsam. Selected intact specimens were placed in vials of alcohol and deposited in the USNM Helminthological Collection, USDA, Beltsville, Maryland 20705: *Bufo alvarius–Aplectana itzocanensis,* 81007; third-stage *Physaloptera* sp., 81009; third-stage *Physocephalus* sp., 81010; *Oswaldocruzia pipiens,* 81008; *Rhabdias americanus,* 81011; *Nematotaenia dispar,* 81012. *Bufo cognatus–Aplectana itzocanensis,* 81013; third-stage *Physaloptera* sp., 81015; *Oswaldocruzia pipiens,* 81014; *Rhabdias americanus,* 81016; *Distoichometra bufonis,* 81017. *Scaphiopus couchii–Aplectana incerta,* 81018; *Oswaldocruzia pipiens,* 81019; *Distoichometra bufonis,* 81020.

Prevalence, location, and mean intensity for each host are given in Table 1. The parasite load, as well as prevalence and intensity of helminths, were different for each host. For *B. alvarius,* 92 of 95 (97%) contained helminths. There were 56 male toads (55 infected; 98%) and 39 female toads (37 infected; 95%) in the sample. The cestode *N. dispar* had the highest prevalence (67%). Greatest mean intensity was recorded for the nematode *A. itzocanensis* (33). There was no significant difference in intensity of infection between male and female toads for *Physaloptera* sp., *O. pipiens, R. americanus,* or *N. dispar* (Kruskal-Wallis statistic = 1.35, 0.5, 0, and 0.37, respectively, 1 df, $P > 0.05$ for each case). A similar statistic was not calculated for *Physocephalus* sp. since only 2 female toads were infected. Significant difference in intensity of infection between male and female toads was found for *A. itzocanensis* (Kruskal-Wallis statistic = 9.7, 1 df, $P < 0.001$). There

was no correlation between total number of helminths and SVL ($r = -0.08$).

For *B. cognatus,* 14 of 21 (67%) contained helminths. There were 6 male toads (4 infected; 67%) and 15 female toads (10 infected; 67%) in the sample. Mean intensity for total helminth load was 10 (1–65). There was no significant difference in intensity of total infection between male and female toads (Kruskal-Wallis statistic = 0.5, 1 df, $P > 0.05$). Parasite species statistics were not calculated because of our small sample size: 1 female infected with *A. itzocanensis*; 1 male, 2 females infected with *Physaloptera* sp.; 1 male, 7 females infected with *O. pipiens*; 1 male, 3 females infected with *D. bufonis*; 2 males, 6 females infected with *R. americanus.* The nematodes *O. pipiens* and *R. americanus* had equally high prevalences (38%). Greatest mean intensity was recorded for *R. americanus* (7). There was no correlation between total number of helminths and SVL ($r = 0.04$).

For *S. couchii,* 69 of 76 (91%) contained helminths. There were 49 male toads (43 infected, 88%) and 27 female toads (26 infected, 96%) in the sample. Highest prevalence and greatest mean intensity were recorded for *A. incerta* (82%, 74, respectively). In contrast to *B. alvarius* and *B. cognatus,* no nematodes were found in the lungs of *S. couchii.* There was no significant difference in intensity of infection between male and female toads for *A. incerta, O. pipiens,* or *D. bufonis* (Kruskal-Wallis statistic = 1.4, 0.35, and 1.46, respectively, 1 df, $P > 0.05$ for each case). There was no correlation between total helminth numbers and SVL ($r = 0.04$).

The most prevalent parasite was the ascarid nematode, *A. incerta.* It was originally described by Caballero (1949) from *Bufo marinus* from Chiapas, Mexico and has been redescribed from type specimens by Baker (1985). It has not been previously reported from other hosts. Likewise, *A. itzocanensis* was originally described by Bravo Hollis (1943) from *Scaphiopus multiplicatus* from Puebla, Mexico. It has also been redescribed by Baker (1985) from *Bufo woodhousii woodhousii* and has been reported in *B. marinus* from Costa Rica (Brenes and Bravo Hollis, 1959) and Veracruz, Mexico (Caballero Deloya, 1974).

Species of the genus *Physaloptera* occur in the stomachs of a variety of terrestrial vertebrates. However to our knowledge, no cases of parasitism of toads by adult physalopterans have been reported. We noted third-stage physalopterans in both *B. alvarius* and *B. cognatus* but not in *S. couchii.* Third-stage physalopterans have also been reported from the toads *Bufo microscaphus* and *B. woodhousii* from Utah (Parry and Grundmann, 1965) and *Bufo americanus* from Ohio (Ashton and Rabalais, 1978). Kuntz (1940) reported the family Physalopteridae as occurring in *Bufo speciosus* (=*compactilis*) and *B. cognatus* but did not name the stage.

Alicata (1935) reported species of the genus *Physocephalus* occur in the stomachs of swine, mice, and rats, in the esophagus and rumen of ruminants, and in the crop of chickens. They are of accidental occurrence in other mammals, birds, reptiles, and amphibians as third-stage larvae (Alicata, 1935). They have not been previously reported in toads. *Physocephalus* sp. requires an insect intermediate host.

Oswaldocruzia pipiens has frequently been encountered in amphibians and is widely distributed in North America. Baker (1978a) studied the life cycle of *O. pipiens* in the frog *Rana sylvatica* and reported prevalence to vary between 61% and 62%. He considered 33% of the *R. sylvatica* to have patent infections. Intensity varied from 1 to 45, but most infected frogs contained 1–5 worms. Our prevalence and intensities fall within Baker's ranges. *Oswaldocruzia pipiens* is infective as third-stage larvae which migrate out of fecal masses into the water column. *Bufo americanus* exposed to contaminated frog feces have become infected (Baker, 1978a). In addition, infection has been reported in *Bufo woodhousii fowleri* by Brandt (1936), Rankin (1945), Campbell (1968); *B. americanus* by Ashton and Rabalais (1978); *Bufo houstonensis* by Thomas et al. (1984); and *Scaphiopus holbrookii* by Brandt (1936).

According to Baker (1987), North American bufonids are apparently infected by a single species of *Rhabdias, R. americanus,* which was described from *B. americanus* by Baker (1978b). Baker (1987) suggested that reports of *Rhabdias bufonis* in *B. americanus* and *B. woodhousii fowleri* from eastern North America (Reiber et al., 1940; Fantham and Porter, 1948; Campbell, 1968; Williams and Taft, 1980) should be referred to *R. americanus. Rhabdias* sp. was listed for *B. speciosus* (=*compactilis*) by Kuntz (1940).

The cestode *N. dispar* is listed in Schmidt (1986) as occurring in the Bufonidae, Ranidae, Sala-

mandridae, Hylidae, and Gekkonidae. It has been reported from the North American toads *B. americanus* by von Linstow (1899), *Bufo terrestris* by Walton (1939), and *B. speciosus* (=*compactilis*) and *S. couchii* by Kuntz (1940).

Distoichometra bufonis was originally described from *B. terrestris* (=*lentiginosus*) by Dickey (1921). It has been reported from *Scaphiopus* sp., *B. terrestris,* and *B. woodhousii fowleri* by Douglas (1958), from *S. holbrookii* by Brandt (1936), from *B. speciosus* (=*compactilis*) and *S. couchii* by Kuntz (1940), and from *Bufo debilis debilis* and *B. woodhousii woodhousii* by McAllister et al. (1989). Hardin and Janovy (1988) reported prevalences of 70–100%, with mean intensities of 2.7–14.8 for *D. bufonis* from samples of *B. woodhousii* from Nebraska. The prevalence reported in our study was much lower, 29% and 20%, respectively, for *B. cognatus* and *S. couchii*. The mean intensities for these toads, 4.0 and 3.0, respectively, are within the values established by Hardin and Janovy (1988).

None of the parasites found in this study were unique to *B. alvarius, B. cognatus,* or *S. couchii,* but those from *B. alvarius* are new host records. Kuntz (1940) reported both *D. bufonis* and *N. dispar* to occur in *S. couchii* and only *N. dispar* in *B. cognatus*. We found *D. bufonis* to occur in both *B. cognatus* and *S. couchii*. *Nematotaenia dispar* was reported only from *B. alvarius*. We cannot explain these host differences.

The toads in this study were collected from localities within the Sonoran desert where their activity is tied to the summer rains which normally begin in July and end in late August. They are inactive and remain underground the rest of the year. Whether the differential gender infection rates in *B. alvarius* by *A. itzocanensis* are an artifact of this sample or a reflection of microhabitat differences remains to be determined.

From Baker (1987) and McAllister et al. (1989) we calculated an average of 4.0 (±5.1 SD) species of nematodes (1–22) for 52 species of the family Bufonidae and a mean of 1.7 (±1.9 SD) species of nematodes (1–7) for 10 species of the family Pelobatidae. The toads in this study fell within the range of what might be expected for members of their respective families. Additional work will be required to determine the reasons for the differences that we report in the helminth fauna of these sympatric species.

Literature Cited

Alicata, J. E. 1935. Early developmental stages of nematodes occurring in swine. U.S. Department Agriculture Technical Bulletin 489. 96 pp.

Ashton, A. D., and F. C. Rabalais. 1978. Helminth parasites of some anurans of northwestern Ohio. Proceedings of the Helminthological Society of Washington 45:141–142.

Baker, M. R. 1978a. Development and transmission of *Oswaldocruzia pipiens* Walton, 1929 (Nematoda: Trichostrongylidae) in amphibians. Canadian Journal of Zoology 56:1026–1031.

———. 1978b. Morphology and taxonomy of *Rhabdias* spp. (Nematoda: Rhabdiasidae) from reptiles and amphibians from southern Ontario. Canadian Journal of Zoology 56:2127–2141.

———. 1985. Redescription of *Aplectana itzocanensis* and *A. incerta* (Nematoda: Cosmocercidae) from amphibians. Transactions of the American Microscopical Society 104:272–277.

———. 1987. Synopsis of the Nematoda parasitic in amphibians and reptiles. Memorial University of Newfoundland, Occasional Papers in Biology 11: 1–325.

Brandt, B. B. 1936. Parasites of certain North Carolina Salientia. Ecological Monographs 6:491–532.

Bravo Hollis, M. 1943. Dos nuevos nemátodos parásitos de anuros del Sur de Puebla. Anales de Instituto de Biología Universidad Nacional del México, Series Zoología 14:69–78.

Brenes, R. R., and M. Bravo Hollis. 1959. Helmintos de la República de Costa Rica. VIII. Nematoda 2. Algunos nemátodos de *Bufo marinus marinus* (L.) y algunas consideraciones sobre los géneros *Oxysomatium* y *Aplectana*. Revista de Biología Tropical 7:35–55.

Caballero, E. 1949. Estudios helmintológicos de la región onchocercosa de México y de la República de Guatemala. Nematoda, 5 Parte. Anales del Instituto de Biología Universidad Nacional de México, Series Zoología 20:279–292.

Caballero Deloya, J. 1974. Estudio helmintológico de los animales silvestres de la estación de biología tropical "Los Tuxtlas," Veracruz. Nematoda I. Algunos nemátodos parasitos de *Bufo horribilis* Wiegmann, 1833. Anales de Instituto de Biología Universidad Nacional del Mexico, Series Zoología 45:45–50.

Campbell, R. A. 1968. A comparative study of the parasites of certain Salientia from Pocahontas State Park, Virginia. Virginia Journal of Science 19:13–20.

Dickey, L. B. 1921. A new amphibian cestode. Journal of Parasitology 7:129–136.

Douglas, L. T. 1958. The taxonomy of nematotaeniid cestodes. Journal of Parasitology 44:261–273.

Fantham, H. B., and A. Porter. 1948. The parasitic fauna of vertebrates in certain Canadian fresh waters, with some remarks on their ecology, structure and importance. Proceedings of the Zoological Society of London 117:609–649.

Hardin, E. L., and J. Janovy, Jr. 1988. Population dynamics of *Distoichometra bufonis* (Cestoda: Nematotaeniidae) in *Bufo woodhousii*. Journal of Parasitology 74:360–365.

Kuntz, R. E. 1940. A study of anuran parasites of Comanche County, Oklahoma. M.S. Thesis, University of Oklahoma, Norman. 93 pp.

———. 1941. The metazoan parasites of some Oklahoma Anura. Proceedings of the Oklahoma Academy of Science 21:33–34.

McAllister, C. T., S. J. Upton, and D. B. Conn. 1989. A comparative study of endoparasites in three species of sympatric *Bufo* (Anura: Bufonidae), from Texas. Proceedings of the Helminthological Society of Washington 56:162–167.

Parry, J. E., and A. W. Grundmann. 1965. Species composition and distribution of the parasites of some common amphibians of Iron and Washington Counties, Utah. Proceedings of the Utah Academy of Science, Arts and Letters 42:271–279.

Rankin, J. S. 1945. An ecological study of the helminth parasites of amphibians and reptiles of western Massachusetts and vicinity. Journal of Parasitology 31:142–150.

Reiber, R. J., E. E. Bryd, and M. V. Parker. 1940.

Certain new and already known nematodes from Amphibia and Reptilia. Lloydia 3:125–144.

Schmidt, G. D. 1986. Handbook of Tapeworm Identification. CRC Press, Boca Raton, Florida. 675 pp.

Stebbins, R. C. 1985. A Field Guide to Western Reptiles and Amphibians. Houghton Mifflin Company, Boston. 336 pp.

Thomas, R. A., S. A. Nadler, and W. L. Jagers. 1984. Helminth parasites of the endangered Houston toad, *Bufo houstonensis* Sanders 1953 (Amphibia, Bufonidae). Journal of Parasitology 70:1012–1013.

Tinsley, R. C., and H. C. Jackson. 1986. Intestinal migration in the life-cycle of *Pseudodiplorchis americanus* (Monogenea). Parasitology 93:451–469.

———, **and** ———. 1988. Pulsed transmission of *Pseudodiplorchis americanus* (Monogenea) between desert hosts (*Scaphiopus couchii*). Parasitology 97:437–452.

von Linstow. 1899. Bericht über die wissenschaftlichen Leistungen in der Naturgeschichte der Helminthen in Jahre 1893. Archiv für Naturgeschichte, Berlin 60:207–248.

Walton, A. 1939. The cestodes as parasites of Amphibia. Contributions from the Biological Laboratories of Knox College 64:1–31.

Williams, D. D., and S. J. Taft. 1980. Helminths of anurans from NW Wisconsin. Proceedings of the Helminthological Society of Washington 47:278.

Research Note

Gastrointestinal Helminths of the Reticulate Gila Monster, *Heloderma suspectum suspectum* (Sauria: Helodermatidae)

STEPHEN R. GOLDBERG[1] AND CHARLES R. BURSEY[2]

[1] Department of Biology, Whittier College, Whittier, California 90608 and
[2] Department of Biology, Pennsylvania State University, Shenango Valley Campus, 147 Shenango Avenue, Sharon, Pennsylvania 16146

ABSTRACT: Examination of the gastrointestinal tract of 110 *Heloderma suspectum suspectum* Cope, 1869, revealed the presence of 1 cestode, *Oochoristica whitentoni* Steelman, 1939, and 2 nematode species, *Oswaldocruzia pipiens* Walton, 1929, and *Skrjabinoptera phrynosoma* Ortlepp, 1922. Helminth prevalence and mean intensity were 12% and 9.9, respectively. These findings represent new host records.

KEY WORDS: Cestoda, *Oochoristica whitentoni*, Nematoda, *Oswaldocruzia pipiens*, *Skrjabinoptera phrynosoma*, Helodermatidae, *Heloderma suspectum suspectum*, Gila monster.

The Gila monster, *Heloderma suspectum* Cope, 1869, is found from extreme southwestern Utah and southern Nevada through southern Arizona and southwestern New Mexico to northern Sinaloa, Mexico from sea level to about 1,520 m (Stebbins, 1985). The few reports of parasitism in this species mostly concern filariae. Smith (1910) recovered 4 adult filariae which he named *Filaria mitchelli*; they were reassigned to the genus *Piratuba* by Chabaud and Frank (1961a). Hannum (1941) described adult and microfilaria of *Chandlerella corophila* which were subsequently reassigned to the genus *Splendidofilaria* by Yamaguti (1961). Ryerson (1949) reported but did not identify microfilariae from 2 Gila